INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS - IRISH GROUP

Development of Gravel Aquifers - a Seminar held at the Montague Hotel, Emo, Portlaoise, January 27- 28, 1981.

Tuesday January 27

10.00 a.m.	Registration
10.30	Introductory Remarks - Dr.D.J.Burdon, President, IAH Irish Group.
10.45	Film - 'Ground Water' (NWWA) - courtesy Ingersoll Rand Ltd.
11.05	Coffee
11.20	Occurrence of Gravel Aquifers in Ireland - Dr.J.R.Creighton, G.S.I.
12.00	Geophysical Investigations of Gravel Aquifers - Brian Williams, Consultant.
12.45 p.m.	Lunch
2.00	Geophysical Investigations - Field Demonstration - Frank Collar, Minerex Ltd.
2.45	Drilling and Sampling Gravel Aquifers - Dr. Lewis Clark, Water Research Centre.
3.30	Coffee
3.45	Films - 'World of Water' and 'Revert', courtesy Johnsons Wellscreens.
4.30	Drilling and Sampling Gravel Aquifers (2)- Dr. Lewis Clark
5.15	Discussion
6.00	Close.

Wednesday January 28

9.30 a.m.	Well Screens and Gravel Packs - W.Jungmann, Johnson Wellscreens Ltd.
10.30	Coffee
10.45	Well Development - W.Jungmann
11.30	Well Development - Field Demonstration
12.30 p.m.	Lunch
2.00	Gravel Aquifer Development - Case Histories - E.P.Daly, G.S.I. - K.T.Cullen, Consultant - Frank Collar, Minerex Ltd. - Peter Bennett, G.S.Northern Ireland - G.R.Wright, G.S.I. - R.Aspinwall, Consultant. - Lewis Clark, WRC
3.30	Discussion

4.00(approx) Closing Remarks .

THE OCCURRENCE OF SAND AND GRAVEL DEPOSITS IN IRELAND

(Dr. J.R. Creighton - Geological Survey of Ireland)

INTRODUCTION

This paper summarises and explains the distribution of sands and graveld by reference to the genesis of the sediments. From a knowledge of the geological history of an area, and particularly the type of deposition involved, some prediction can be made of the location, extent and characteristics of the gravel deposits. After an examination of geological maps, aerial photographs and borehole records, geophysical survey and drilling can add further information. The silt/sand boundary is taken at 0.06mm and that of sand/gravel at 2.0mm.

ORIGINS

Sands and gravels are transported in 'high energy' environments, where water, flowing at high velocity, has the competence to carry such coarse sediment. With decreasing competence, these sands and gravels are deposited first.

1. Glacial:

This is the most important origin of sand and gravel in Ireland. They were deposited by the ice itself, but mostly by glacial meltwater rivers around the margins of the ice sheets. The deposits can take various forms such as:

(a) Moraines: ridges of sand, gravel and clay, poorly sorted, angular stones, rapid changes in grain size.

(b) Kames: mounds forming distinctive 'kame-and-kettle' topography, usually well-sorted with rounded stones e.g. Screen Hills, Wexford.

(c) Eskers: distinctive long sinuous ridges, steep-sided and well-sorted. They may be above the watertable e.g. Tullamore.

(d) Deltas: flat-topped and steep-sided mounds deposited in former lakes. Steeply plunging beds of well-sorted sediment, often overlying silts and clays and overlain by coarser poorly sorted gravels e.g. Blessington, Fassaroe, Co. Wicklow.

(e) Outwash Plain: flat or undulating plain of well-sorted, horizontally bedded sands and gravels e.g. Curragh. In valleys, the plain of deposition is confined, thus infilling the valley as a 'valley train', the remnants of which are seen as terraces on the valley sides e.g. Slaney Valley, Co. Wexford.

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2. Coastal:

Changes in sea level have resulted in the formation of 'raised beaches', found above modern sea level. They form broad shingle ridges of well-sorted, rounded cobbles in a sandy matrix. They may be dry e.g. Laytown and Bettystown, Co. Meath: Baltroy and Dromiskin, Co. Louth. Extensive modern beach and dune systems are found around the coastline. They are composed of mainly well-sorted sands. They have good infiltration rates but may present salinity problems.

3. Fluvial:

River alluvium can infill valleys to considerable depths. Subsequent erosion can result in a series of terraces on the valley floor. The alluvium may be poorly sorted and contain considerable silt and clay, as modern rivers in Ireland have a limited competence, in comparison to the glacial rivers for example. However they are likely to be saturated and obtain good recharge from the river. Such gravels are important where they attain considerable thicknesses such as in deep buried channels eroded at a time of lower sea level, or in confined rock basins along a valley eg. River Lee in Cork.

REGIONAL DISTRIBUTION

Major sand and gravel complexes can be identified, and their location and type related to the pattern of ice decay. A regional subdivision can be made as follows:

(a) Kildare, West Wicklow, Carlow;
(b) East Wicklow, South Wexford;
(c) South Tipperary, Limerick;
(d) Midlands (Offaly, Laois, N. Tipp. E. Galway, E. Mayo);
(e) Meath, Westmeath, Louth;
(f) Peripheral upland areas.

CONCLUSION

A knowledge of the glacial history of an area is invaluable in the location of sands and gravels. Their occurrence is not completely predictable, but broad guidelines can be established for further exploration. The main areas are known, though they require more

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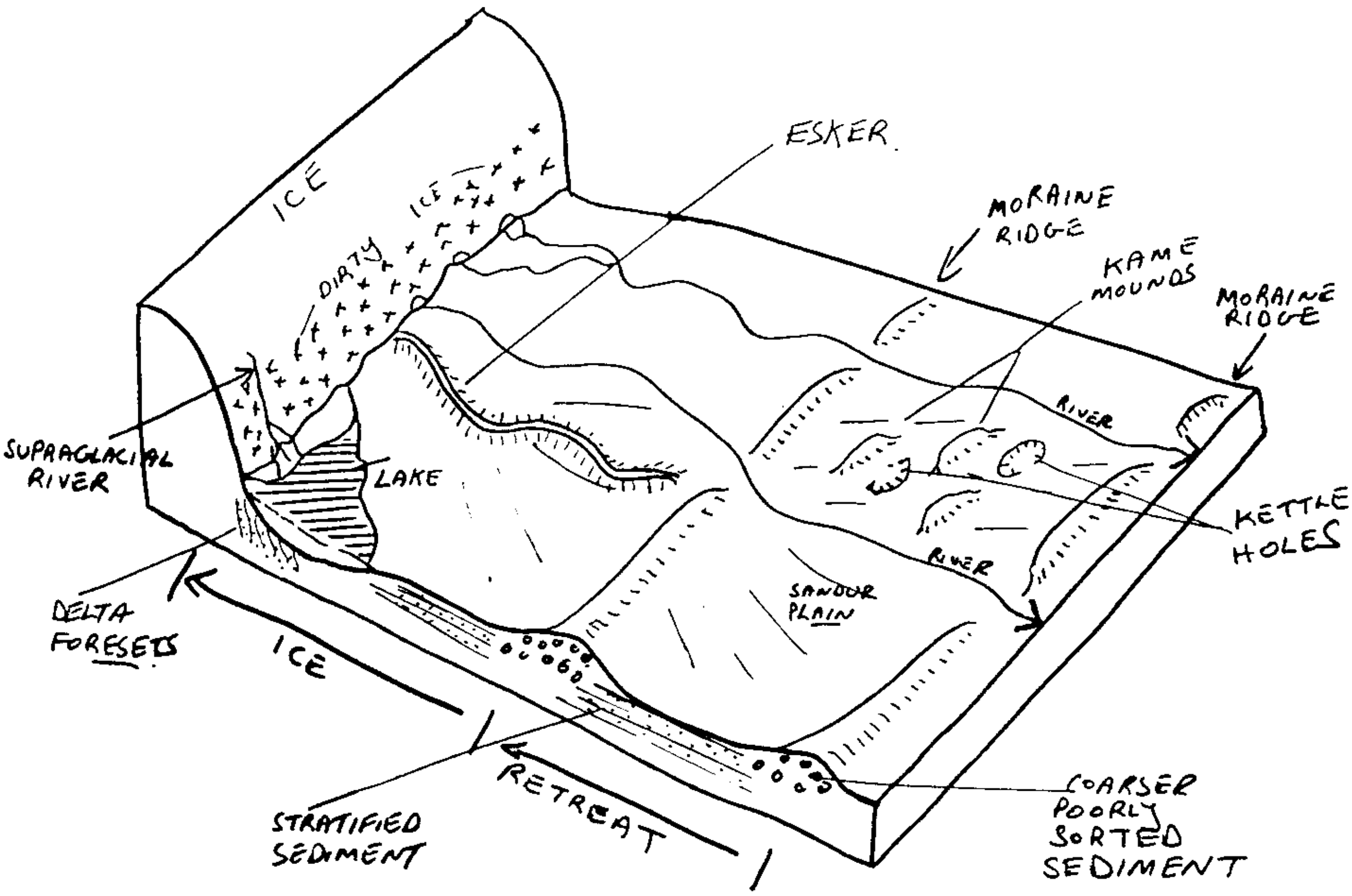
detailed survey. For other areas relatively little is known. Subsurface location of deposits is dependent on the accumulation of good borehole records particularly for the estimation of depth to bedrock, which acts as a considerable control on aquifer development. 10m would be the minimum thickness required. A lack of uniformity in sediment type, as well as variations in vertical thickness and lateral extent, are more often the rule than the exception. Only by the continued accumulation of data can discovery and interpretation be improved.



DRILLING AND SAMPLING GRAVEL AQUIFERS

- L. Clark, Water Research Centre

A. D R I L L I N G

1. WHAT ARE GRAVELS?

River Terrace Deposits

Glacial Deposits - Moraines

Mixed - Fluvioglacial Deposits

The important features from the drilling point of view are:

(a) They are generally not pure gravels but are usually interbedded with sands and clays;

(b) They vary widely in thickness;

(c) They are unconsolidated and require support.

These features dictate the selection of drilling methods that can be used for any particular location.

2. METHODS OF DRILLING IN GRAVELS

There are many drilling techniques but the overwhelming majority of water wells are drilled using one of three methods:

Percussion Drilling

Rotary Drilling with reverse circulation

Rotary Drilling with direct circulation.

Each of these uses a different technique to support the unconsolidated sediments. I would like to give three definitions here before discussing drilling methods:

Casing — is tubing put down a borehole to support the sides. It can either be a temporary or permanent installation.

Screen — is perforated tubing put down a borehole opposite the water-bearing sediment to let water in but keep the sediment out. Screen can be a sophisticated design like Johnson screen or simple casing with slots cut in it.

Casing and screen can be of any material - stainless steel, mild steel, PVC, ABS and fibreglass are now very common.

An Aquifer — is a water-bearing formation - in this discussion either gravel or sand.

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3. SHALLOW GRAVEL DRILLING

I define shallow gravels as those deposits less than about 40 metres thick. This definition has only one significance: 40 metres is about the limit for percussion drilling and below this depth the rotary methods are usually better.

Rotary methods can be used in shallow drilling but percussion has many advantages in these circumstances. The chief advantage of the rotary methods is their speed and if well-fields of tens of wells, or hundreds as in Pakistan, are to be drilled then a rotary method will usually be used. When only one or two wells are to be drilled the percussion method is usually used and it is a fact that most shallow wells are drilled by this method.

4. PERCUSSION DRILLING

In this method a heavy bailer or shell is suspended on cable running over the drilling rig mast. The cable is moved up and down by means of the spudding arm on the rig which works on a cam system. The reciprocating action of the shell enables it to cut down through the unconsolidated formations. As the hole progresses the cut material is held in the shell by a flap-valve on the bottom. The shell is emptied periodically to empty the borehole and provide formation samples.

The sides of the hole are supported by a string of temporary steel casing. The bottom of the casing has a special cutting edge or 'shoe' and the top of the casing has a special heavy duty drive-head. The casing is advanced behind the shell either by its own weight or by driving using the weight of the shell on the drive-head. The casing is usually driven in when the shell has advanced one or two metres past the cutting shoe. The casing string is made up usually of casing lengths 2-3 metres long with flush screw-threaded joints to allow a continuous advance.

The drilling and casing advance to the designed depth of the borehole - usually the bottom of the gravels. The permanent casing and screen are then lowered into the hole and the temporary steel casing removed.

This need to drive and then pull the temporary casing against the friction of the unconsolidated formation is the reason why this drilling method is limited to relatively shallow depths.

There are variations on the shell method of percussion drilling but the principles are the same. With small wells a very simple rig can be used - merely consisting of a tripod.

In hard formations a chisel can be used instead of the shell to break up the formation, the shell being used to remove the shattered samples. The advantages of the percussion method are:

Simplicity;

Low capital and running costs;

Low demand for drilling water;

Ability to drill anywhere;

Excellent sample recovery.

I shall be dealing with the question of formation and water sampling later.

5. <u>ROTARY DRILLING</u>

The limits of the percussion method are generally met when friction between the casing and gravel prevents the casing being driven any further. Another limiting case is when the drilling meets running sand which fills the casing as fast as the shell can remove it. In either case the only methods of advancement are the rotary methods.

The common method of rotary drilling is that using <u>direct circulation</u>. With direct circulation rotary drilling, no temporary casing is used. The hole is kept open by the pressure of circulating fluid, sometimes water, but more commonly drilling mud - a mixture of bentonite clay and water. The consistency of the mud must be such as to allow it to be pumped through the system, to pick up the cuttings from the bit but to allow the cuttings to drop out in the settlement tanks or mud pits.

The mud is mixed in the mud pits then pumped through the kelly hose to the top of the drill string. It then passes down the drill string to the bit where it picks up the cuttings and then passes up the borehole outside the drill string to the surface. It is directed through a channel back to the mud pits. There are usually two pits - the first one to allow coarse cuttings to settle out and the second one used as a mud reservoir ready for recirculation.

The mud serves three main purposes:

(a) It cools the bit;

(b) It picks up the drill cuttings;

(c) It provides hydrostatic pressure to hold up the hole.

In the latter case it is helped because the hydrostatic pressure tries to force the mud into the formation but the formation acts as a filter and gradually a solid layer of bentonite or mud cake builds up on the well face to act as a support. The mud cake also prevents excessive fluid loss to the formation.

The drill string has several components. At the top is a swivel joint to allow the string to rotate. The main part of the drill string is of drill pipes usually 3 to 10 metres long which are added as drilling progresses. The bottom lengths of the string are very heavy pipes called drill collars added to give weight. At the bottom of the string is a drill bit of which there are numerous designs - the commonest is a tricone bit.

The direct circulation rotary method has disadvantages:

(a) It is clearly much more complex than percussion and is, therefore, more expensive;

(b) It requires a large site and good access for all the plant and pits;

(c) It requires a higher calibre driller and crew;

(d) Sampling is generally difficult and unreliable;

(e) It muds-up the aquifer.

It does have two over-riding advantages over the percussion methods:

(a) It is rapid - I have seen penetration rates of over 30 metres a day in Thailand;

(b) It has no depth limitation. We completed wells in Thailand 200 metres deep (600 feet) in thick gravels.

<u>Reverse Circulation Rotary drilling</u> has similarities to the direct circulation method but has some quite distinctive features. The drilling fluid is circulated in the opposite direction by being pumped up the drill stem into the settling pit and then returning to the borehole by gravity flow. The water ways in the system are much larger than in the direct circulation system and the drill stem is made up of 6" or 8" ID flanged pipes. The fluid is generally water - water from the formation topped up by an external supply. The water supply has to be sufficient to maintain the level in the borehole at the surface and cope with substantial losses to the aquifer. It is this imposed hydrostatic head which keeps the aquifer supported in the borehole. The large diameter pipes used in reverse circulation mean the system is not used for narrow wells - a minimum diameter for a reverse circulation well is about 14".

The advantages of the system are:

(a) Very rapid drilling at large diameters;
(b) No mudding-up of aquifer;
(c) No depth constraint;
(d) No casing needed;
(e) Good sampling.

Its main disadvantage, apart from high costs similar to direct circulation, is that it needs a lot of back-up water.

B. SAMPLING

WHY FORMATION SAMPLING IS IMPORTANT

A water well in unconsolidated formations is lined with a casing/screen string designed to support the formation but let the water through.

It is important to know where the different formations are so that the screen sections can be positioned exactly opposite the aquifers. It is also important to know how coarse the formations are so that the correct screens can be used.

The different drilling methods have different sampling capabilities.

PERCUSSION DRILLING

The percussion method enables a continuous record of the formation to be kept with great accuracy. As the borehole advances the shell removes each layer of sediment as it is encountered. The sediment is brought up in the shell and is immediately available for sampling and sieving. Its depth of origin is known within a few centimetres.

The samples taken are sieved to determine the grain size distribution for screen design. The samples are used to make borehole logs.

The sampling by percussion methods is generally very good but there is almost always a loss of the finer elements. The loss is usually not important but should be borne in mind when selecting the screen.

Undisturbed samples can sometimes be obtained in finer gravels and sand by driving a solid steel tube into the formation at the bottom of the hole. Special tubes are now available for this work at a standard diameter of 4" (100 mm) called U_4 tubes. A U_4 sample has to be pushed out of the sample tube but then allows one to see exactly what a formation is made of.

ROTARY DRILLING ; REVERSE CIRCULATION

The direct circulation method uses mud to carry debris out of the hole. Disturbed formation samples are obtained by letting the mud pass over a settling collector, usually a bucket, as it passes out of the borehole.

The quality of the samples is usually poor and they need a lot of interpretation:

(a) Few fines settle out in the bucket; most of the fines that do settle are then washed out when the bentonite is rinsed from the sample. The result is an almost total loss of fines;

(b) The cuttings are supposed to settle out. Many do but inevitably there is some recirculation and mixing of samples. In Thailand for example, drilling through alternating sands and clays, after hitting the first sand, we could not pick out any other clay or sand bed. All samples were contaminated with sand.

Despite these drawbacks disturbed samples should be taken. The bucket is put in the mud channel, the bit is advanced for the sample interval, say 2 metres then drilling stops but the mud circulation continues until the cuttings have cleared the hole. The process is repeated. Alternatively continuous sampling can be undertaken but then allowance has to be made for the time taken for the sample to travel up the borehole into the bucket.

If a pure sample is needed then a core of the formation can sometimes be taken although this is very difficult in sands and gravels.

The poor quality of formation samples from direct circulation mud flush holes means, to me, that it is essential to geophysically log all these boreholes. I would recommend logging of all holes, but for mud flush holes it is essential. Geophysical logging is the only way to be sure of putting your screen exactly opposite the formation you want.

REVERSE CIRCULATION

Reverse circulation can produce excellent samples. The method uses clean water therefore the hole is not mudded up nor are the samples.

Settlement is good so there is little recirculation and cross-contamination of samples.

The samples are sucked up the inside of the rising main (6" ID) so there is little crushing of gravels. A coarse gravel will be sampled whole whereas in Direct Circulation the large stones will be crushed to coarse sand by the tricone before being flushed from the hole.

The major difficulty in reverse circulation sampling is the actual collection of the sample. The return flow is ejected into the settlement pit with considerable force - collecting from it can be similar to sitting in a mortar barrage. One can deflect some of the flow into a manageable collecting container but inevitably there will be some loss of the finer materials from the samples.

The order of sampling quality is:

(a) Core or U_4 (IF POSSIBLE);
(b) Percussion samples;
(c) Reverse circulation samples;
(d) Direct circulation samples.

In all cases I would recommend confirmation of the sample logs by geophysical logs. This is absolutely essential with direct circulation holes.

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ELECTRICAL RESISTIVITY SURVEYING: AN INTRODUCTION.

The electrical resistivity method can be used quickly and economically to obtain details about the location, depth and resistivity of subsurface formations.

The basis of the method is that when current is applied by conduction into the ground through electrodes, any subsurface variation in conductivity alters the current flow in the earth and this in turn affects the distribution of electric potential. It is therefore possible to obtain information about the subsurface from measurements of electric potential (i.e. voltage) made at the surface.

The usual practice is to pass current into the ground by means of two electrodes (generally steel stakes) and to measure the potential (or voltage) difference between a second pair placed in-line between the current electrodes. The apparent resistivity at the surface is calculated by dividing the measured voltage difference by the applied current and then multiplying by a constant derived from the electrode separation.

i.e. apparent resistivity, $Pa = \frac{V}{I} \times Ke$

In homogeneous ground this is the true ground resistivity - the specific resistivity - but usually this apparent resistivity measured at the surface is a weighted average of the various resistivities of the ground through which the electric current has passed.

It is the variation of this apparent resistivity with change in electrode spacing and position that gives information about the variation in subsurface layering.

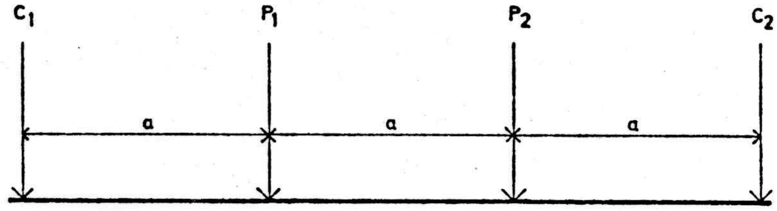
There is no specific correlation of lithology with resistivity but in general the commonly occurring lithologies encountered in water exploration have the following order of increasing resistivity:- clays and marls, top soil, glacial boulder clay, sandy soils, loose sands below the water table, argillaceous limestones, sands above the water table, sandstones, limestones, metamorphosed rocks, granites. There are, however, great variations in resistivity since the resistivity depends on several factors. Electrical conduction in most rocks is mainly electrolytic with conduction taking place through the interstitial water between the insulating rock grains. Thus the resistivity of a formation is dependent on the resistivity of the contained waters and is inversely dependent on the porosity and the degree of saturation of the formation.

There are two basic methods of carrying out the resistivity measurements and the one chosen depends on the problem under investigation. The first method is "VERTICAL ELECTRICAL SOUNDING" and is used to determine the vertical changes in the resistivity of the subsurface layers and the depths to the discontinuity horizons. In general the electrodes are placed in a straight line at a certain distance apart and for each measurement the distance between the electrodes is increased about a fixed central point. The graph of apparent resistivity versus electrode spacing is then plotted and interpretation of the resulting curve yields an estimate of the thicknesses and resistivities of the subsurface layers.

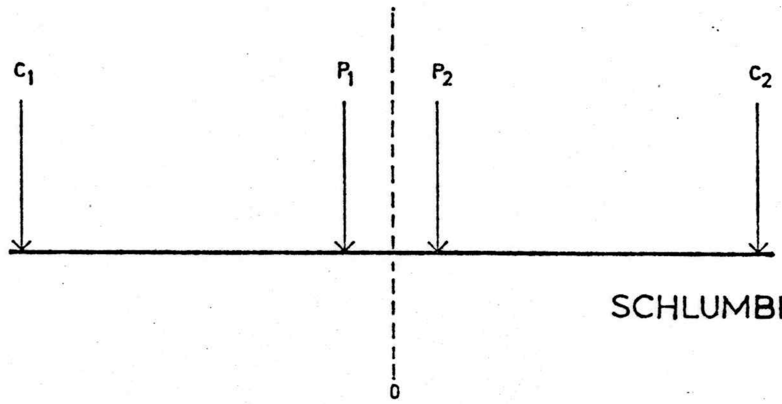
The second method is known as "CONSTANT SEPARATION PROFILING" and is used to determine the variation in resistivity over an area. The electrodes, normally in a straight line, are kept a fixed distance apart and are moved together across the ground in the direction of the line to be surveyed. The resulting data from several profiles can be contoured to give a plan of high and low resistivity materials.

The advantage of the resistivity method is that it has great resolving power. The source-detector separation can be altered to give optimum separation which effectively controls the depth of measurement. In general the depth penetration is increased with the separation of the electrodes. The method of resistivity surveying depends on the particular target and geological situation at each site to be investigated and these features can be evaluated by a hydrogeologist or geophysicist.

The cost of resistivity surveying is dependent on the depth of investigation to be considered but generally shallow sand and gravel acquifer investigation is cheap, costing approximately £150 per day at 1981 prices. However, supervision and interpretation will probably add a further £50 per day to this for the final solution.



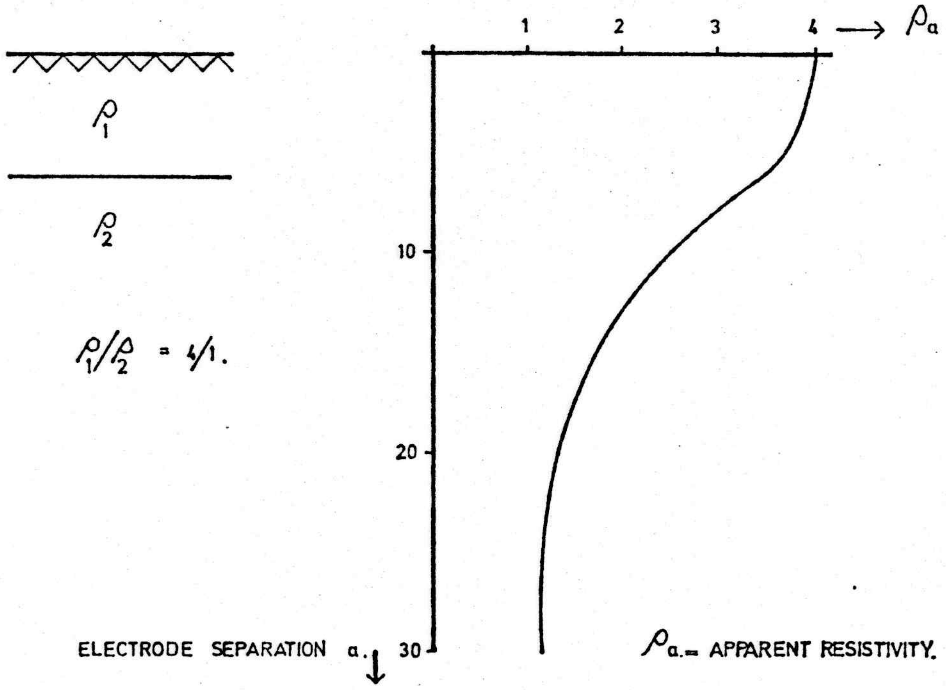
WENNER.



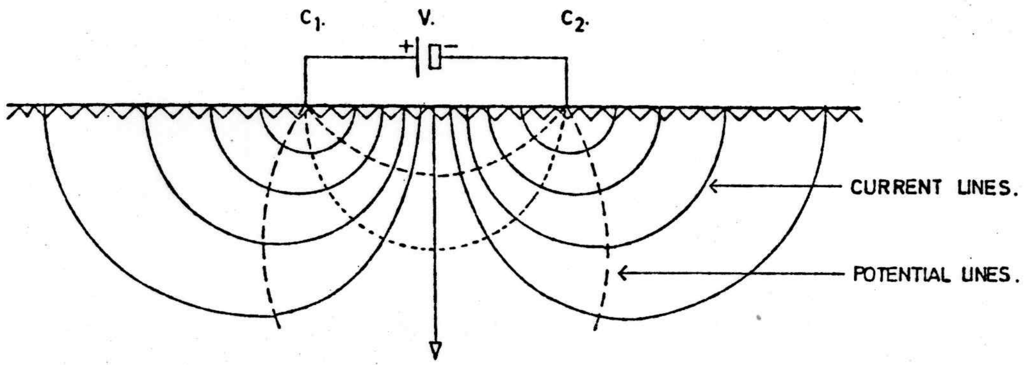
SCHLUMBERGER.

MODEL.

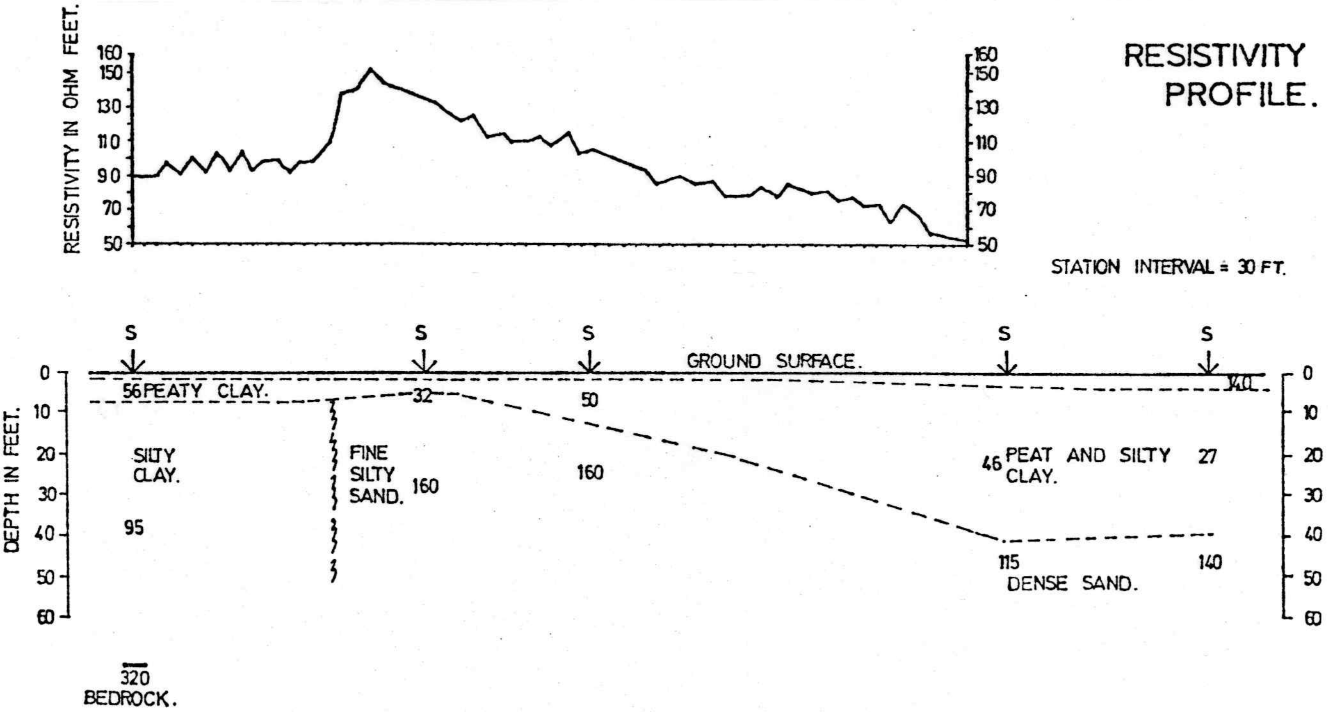
CURVE.



EXAMPLE OF SOUNDING CURVE.



POTENTIAL DISTRIBUTION IN EARTH.



RESISTIVITY PROFILE.

GEOLOGICAL SECTION.

GEOPHYSICAL INVESTIGATIONS AT THE MONTAGUE HOTEL.

In order to confirm the presence of a gravel deposit, reported to underlie the Montague Hotel grounds, a number of electrical resistivity soundings (using a Wenner array) were carried out early in December 1980.

A battery powered GTE rhometer was used in the investigation. Two full soundings (with maximum "a" spacings of 48 and 64m) and two half soundings ("a" spacings of 8m, 16m and 24m) were carried out. The locations of the spreads are shown on Fig. 1. As a result of the built-up nature of the area it was not possible to keep either of the full spreads free of overhead cables. Interpretation used the Zhody and Ghosh methods on an IBM 360 computer.

The four layer curve (with resistivities of 90, 150, 350 and 1,000 Ω m and interface depths of 1, 4 and 11m) shown on Fig. 2 gives a good fit to the field data shown on the same diagram. The fit of the three layer curve (with resistivities of 130, 160 and 350 Ω m and interface depths of 1 and 4m) to the field data of sounding 2 is not as good (Fig. 3). The fit could be improved by reducing the resistivity of the middle layer to 150 Ω m.

The hotel grounds appear to be underlain by boulder clay (90 - 150 Ω m), sands and gravels (350 Ω m) and limestone bedrock (1,000 Ω m). Bedrock has not been reached in sounding 2, hence it is probably over 20m deep in this section. Sounding 1 suggests that bedrock is at 11m and the gravels are 6m thick. However these depths slightly underestimate the true depths as the rock surface is clearly dipping to the southwest.

From the above it can be concluded that the area surrounding the hotel is underlain by a bedrock depression, striking southeast which has been infilled with boulder clay and sand and gravel.

E.P. DALY,
GROUNDWATER DIVISION

January, 1981.

COR.

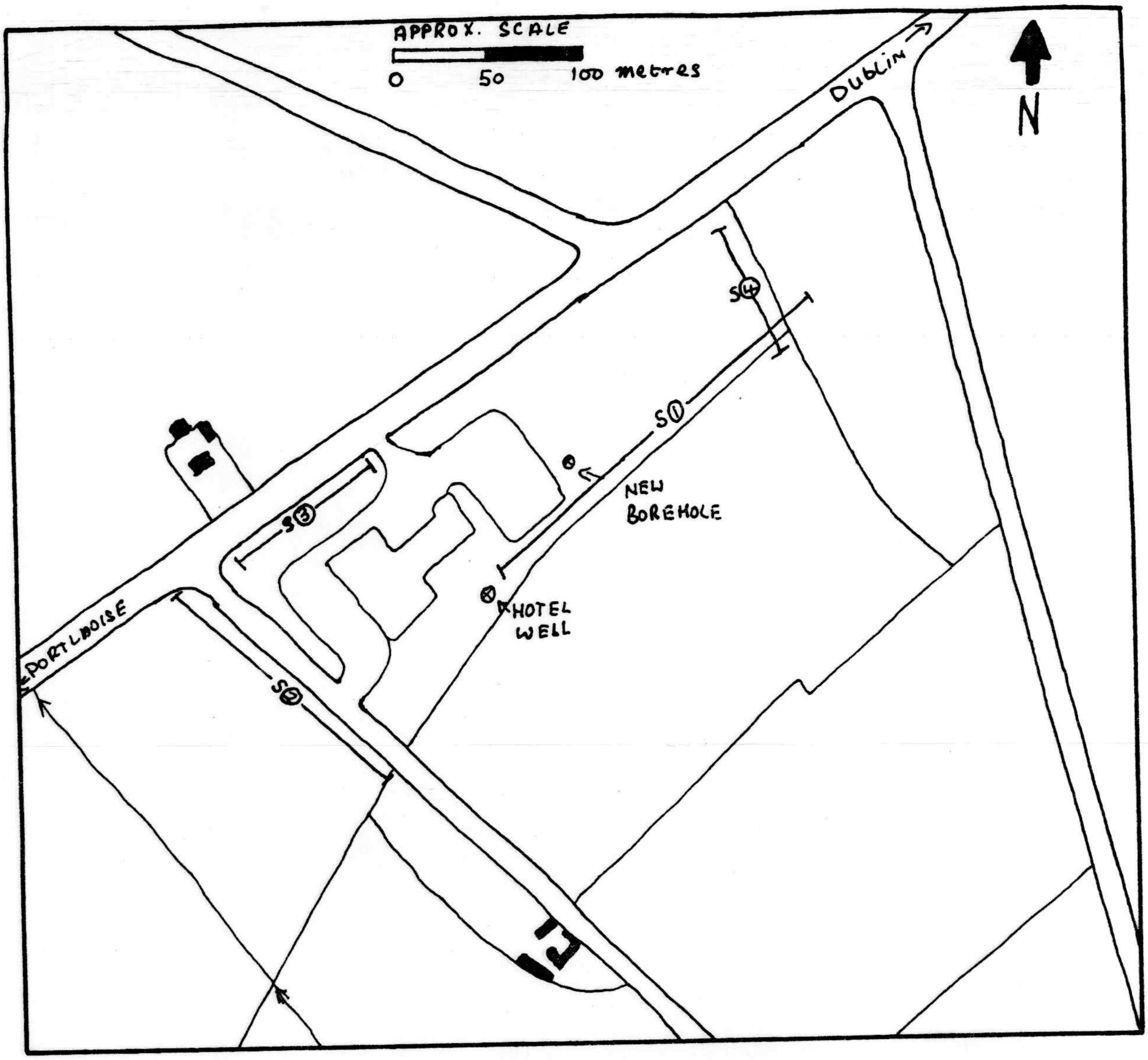


FIGURE I. SITE MAP AT THE MONTAGUE HOTEL

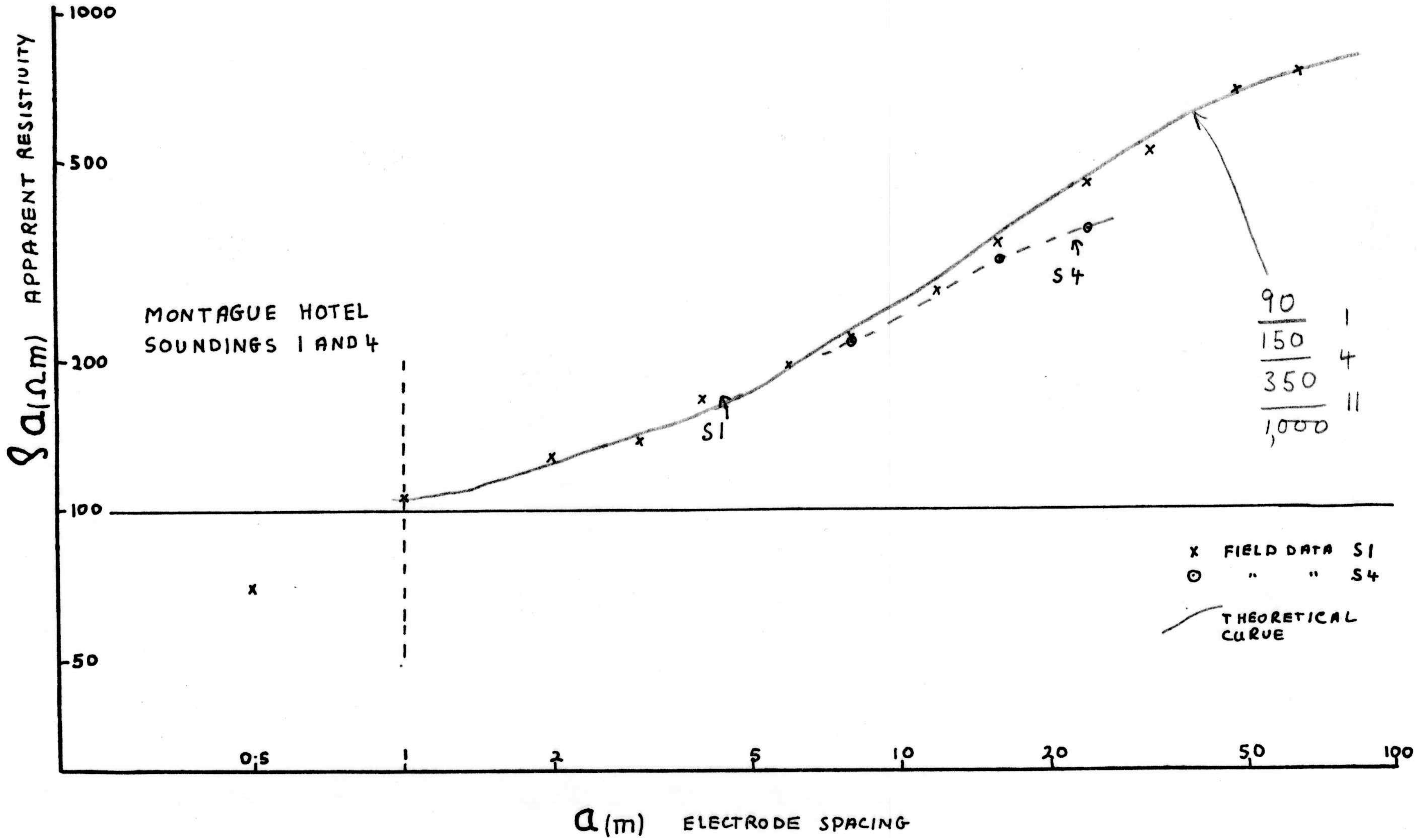

MONTAGUE HOTEL
SOUNDINGS 1 AND 4
ρa(Ωm) APPARENT RESISTIVITY
1000
500
200
100
50
0.5
1
2
5
10
20
50
100
a(m) ELECTRODE SPACING
S1
S4
90
1
150
4
350
11
1,000
x FIELD DATA S1
o " " S4
THEORETICAL CURVE

Figure II.

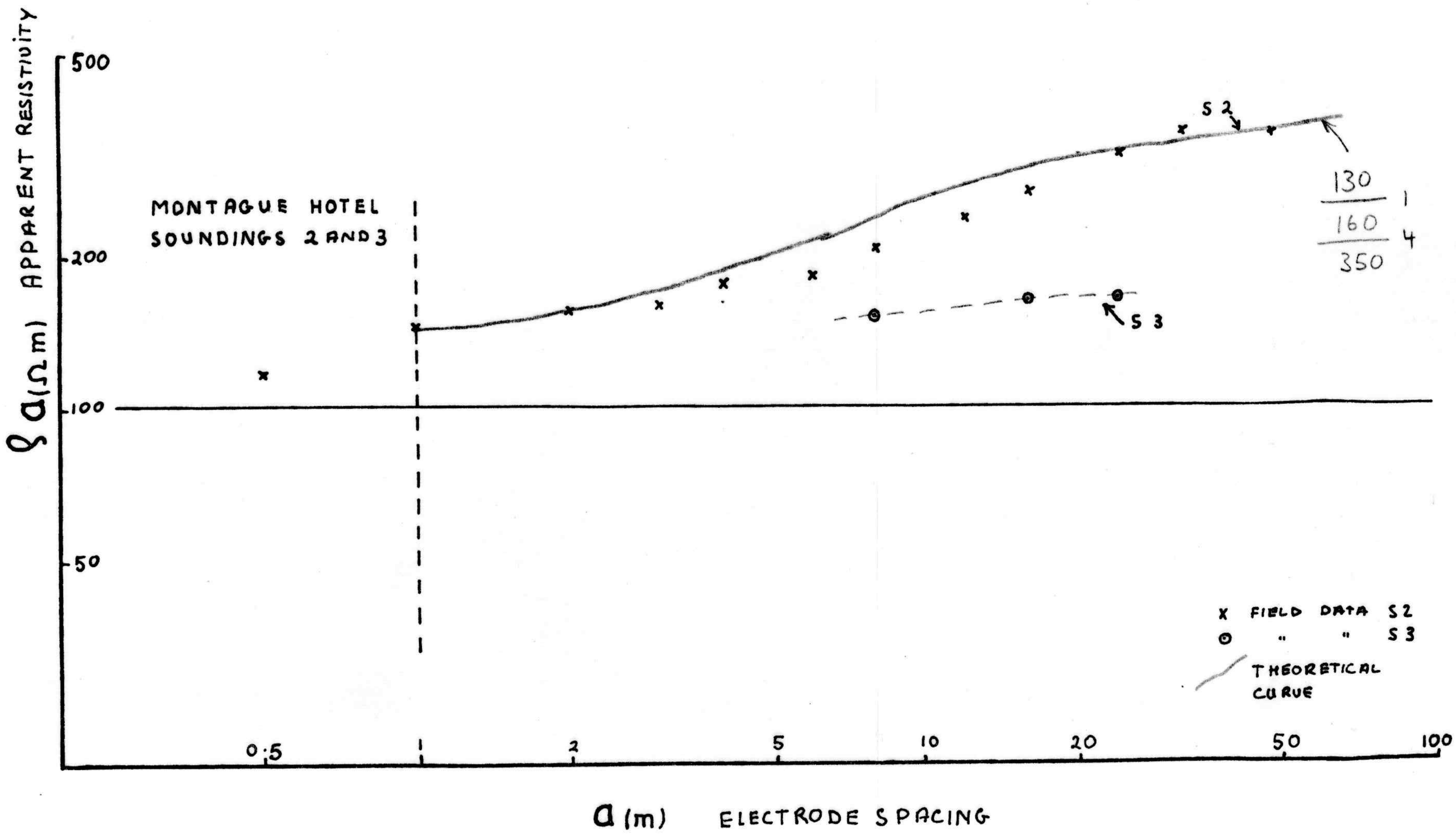
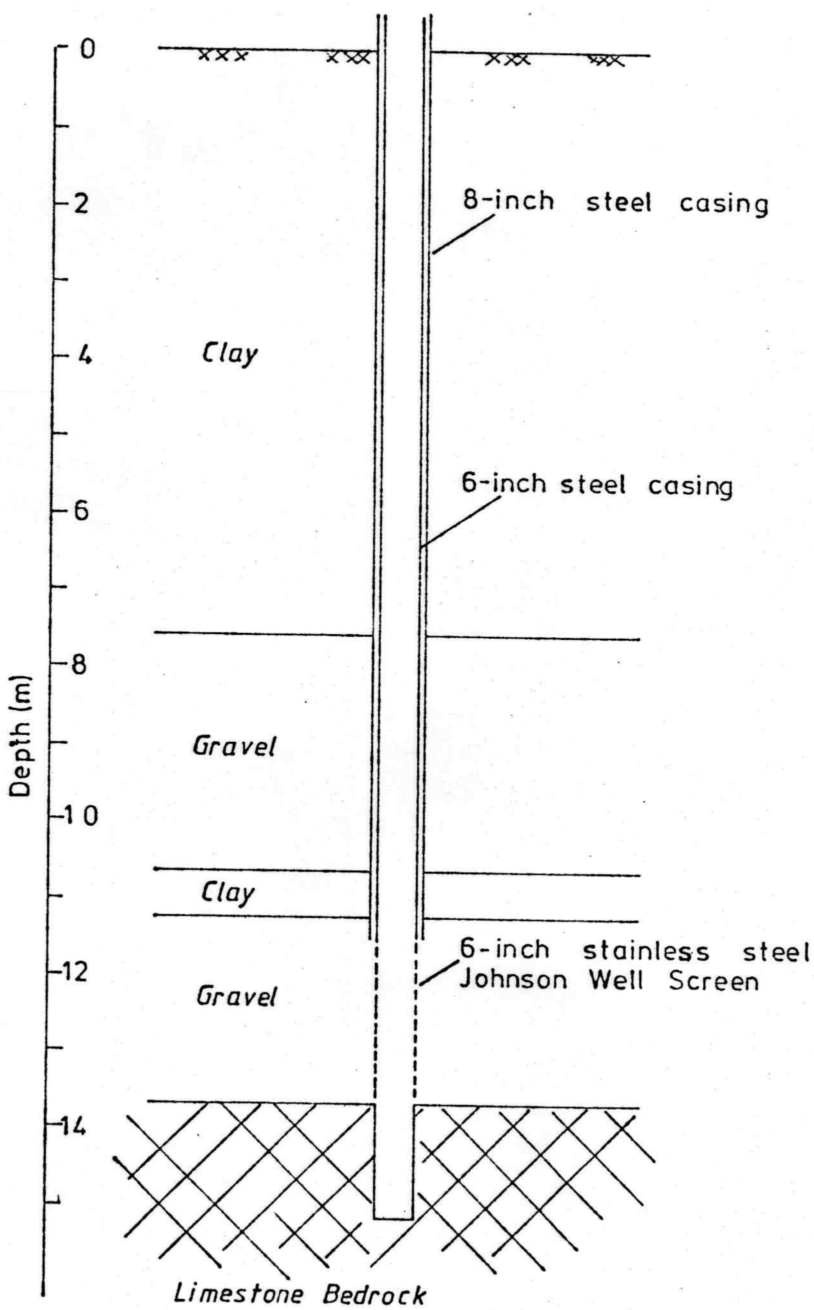

APPARENT RESISTIVITY
$\rho_a (\Omega m)$
500
200
100
50
MONTAGUE HOTEL
SOUNDINGS 2 AND 3
S 2
S 3
130
1
160
4
350
x FIELD DATA S2
⊙ " " S3
THEORETICAL CURVE
0.5
1
2
5
10
20
50
100
a (m) ELECTRODE SPACING

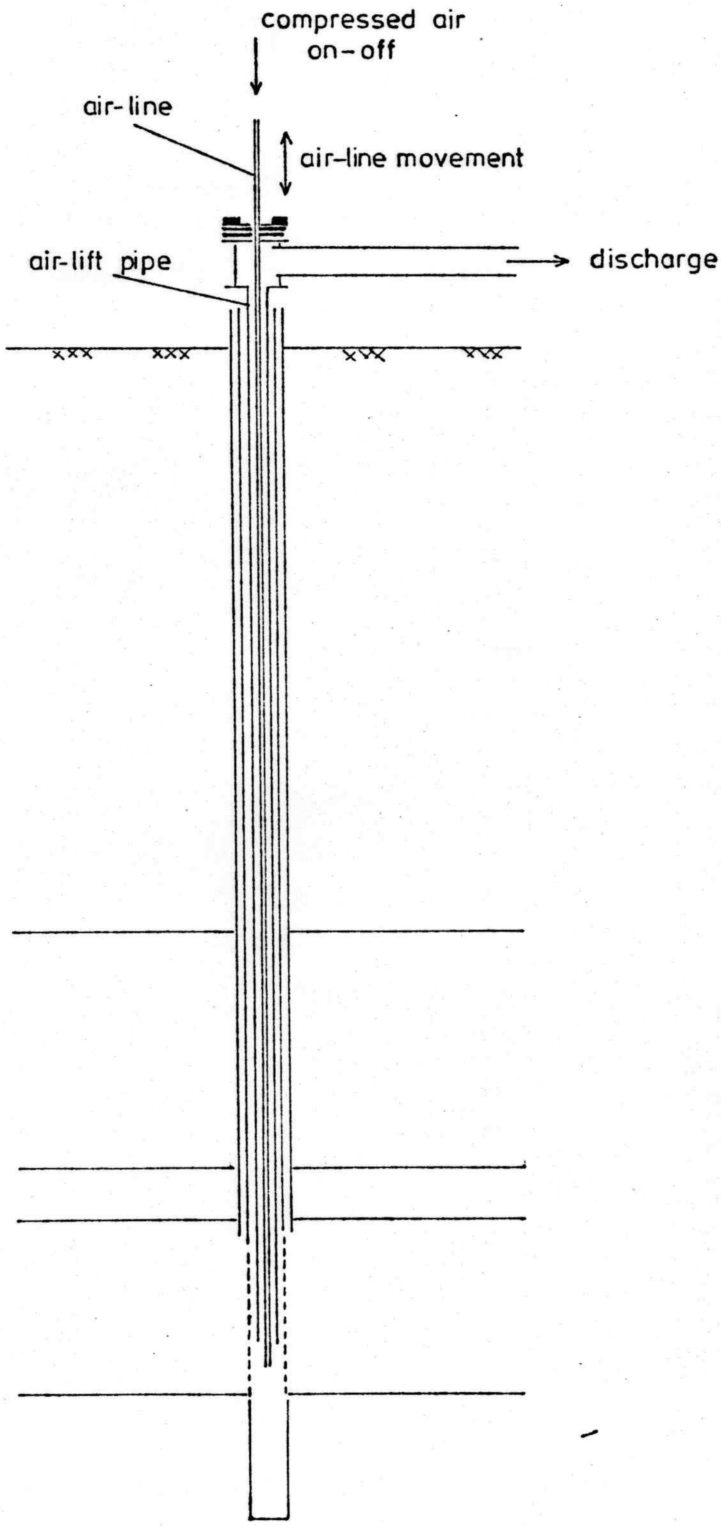
Figure III.

DESIGN AND GEOLOGICAL LOG OF I.A.H. WELL
AT THE MONTAGUE HOTEL

Drilled by; Dunnes Well Drilling, Mallow
Screen supplied by; Johnson Well Screens (Irl) Ltd.



DEVELOPMENT OF I. A. H. WELL AT THE MONTAGUE HOTEL WITH COMPRESSED AIR



CASE STUDY: THE KILMANAGH RIVER GRAVELS

This aquifer occupies an area of about 55 sq. Kms. and is situated on the southeast side of the Slieveardagh Hills north of Callan, Co. Kilkenny. The aquifer can be divided into two parts, an upland area (120-210m) underlain by Namurian shales and sandstones and a lowland area (60-120m) underlain by Dinantian limestones.

The aquifer consists of very coarse poorly sorted sands and gravels, of fluvioglacial origin, interbedded with till (boulder clay). In the lowland area the gravels become finer and are underlain by a thick clay. Geophysical investigations showed the aquifer to be quite narrow and thickest in the centre of the river valley.

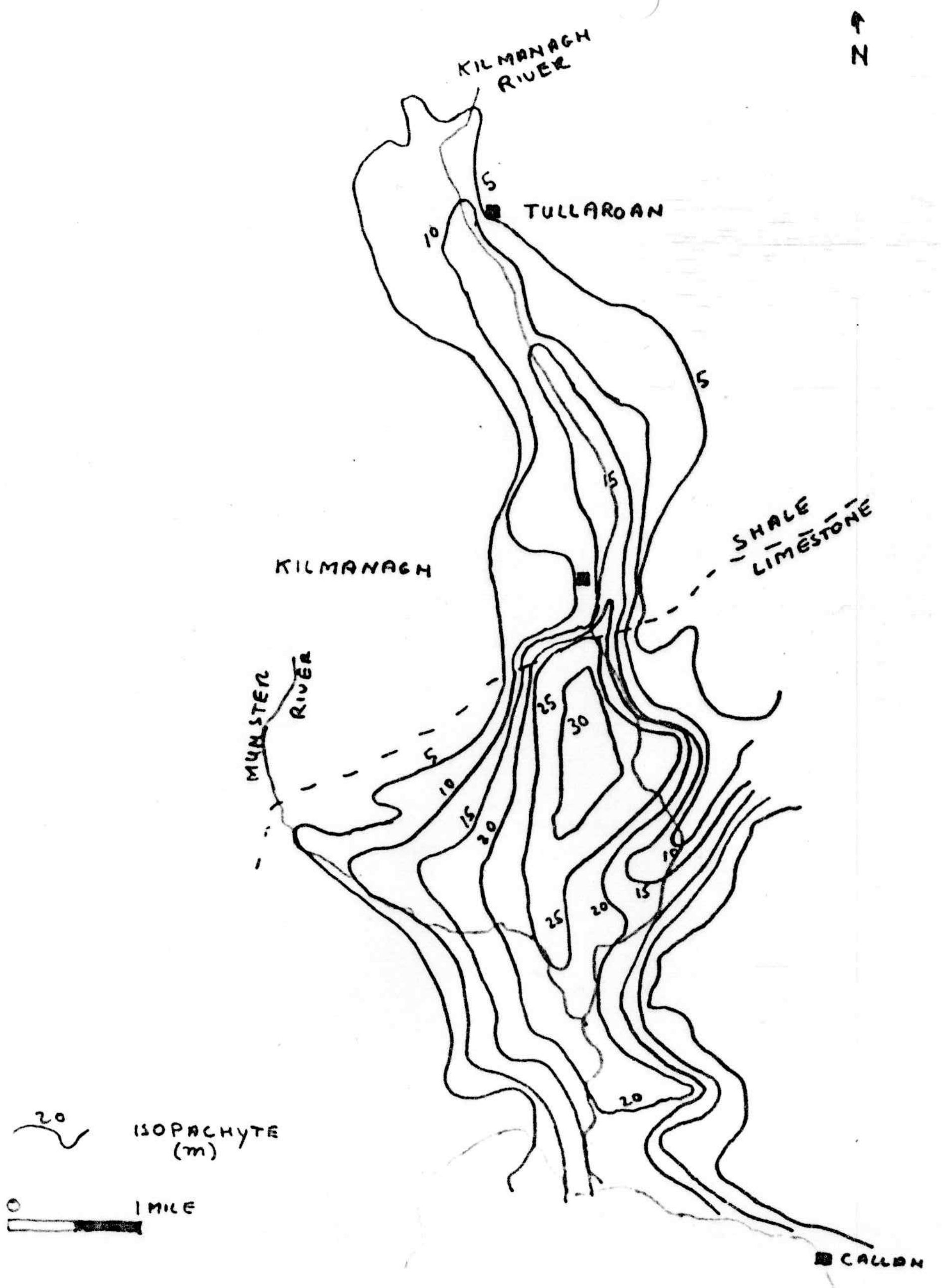
In places the Kilmanagh River is in continuity with the aquifer and becomes influent in the summer. Transmissivity in the aquifer is quite high but storage relatively low. Hydrochemical investigations were used to confirm the flow regime in the aquifer.

Three boreholes were subsequently drilled, logged, screened and tested. The step drawdown tests illustrate the advantages of using the correct length and size of screen.

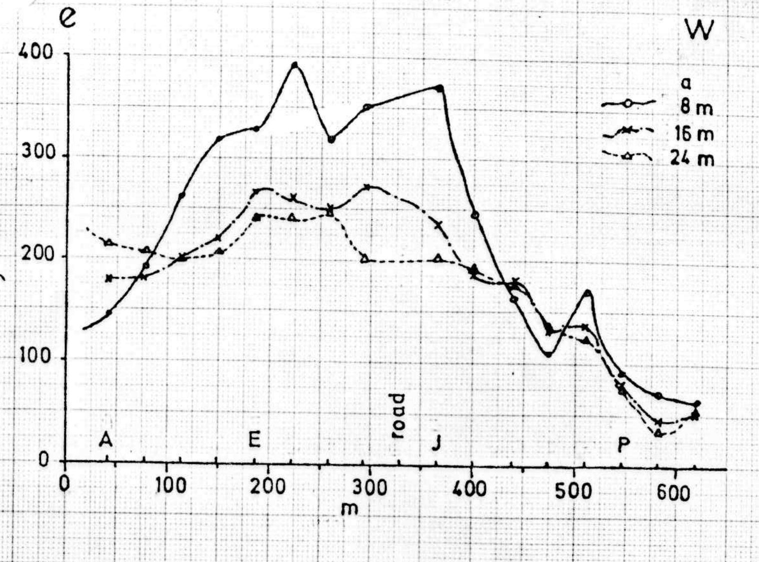
E.P. Daly,
Groundwater Division.

January, 1981.

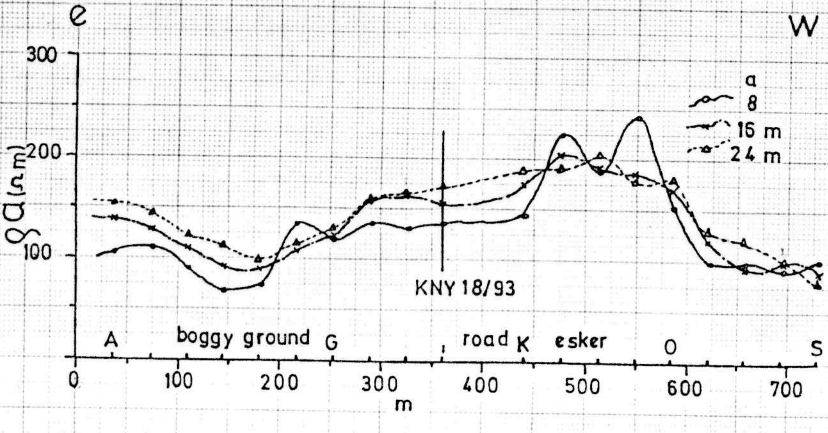
COR.



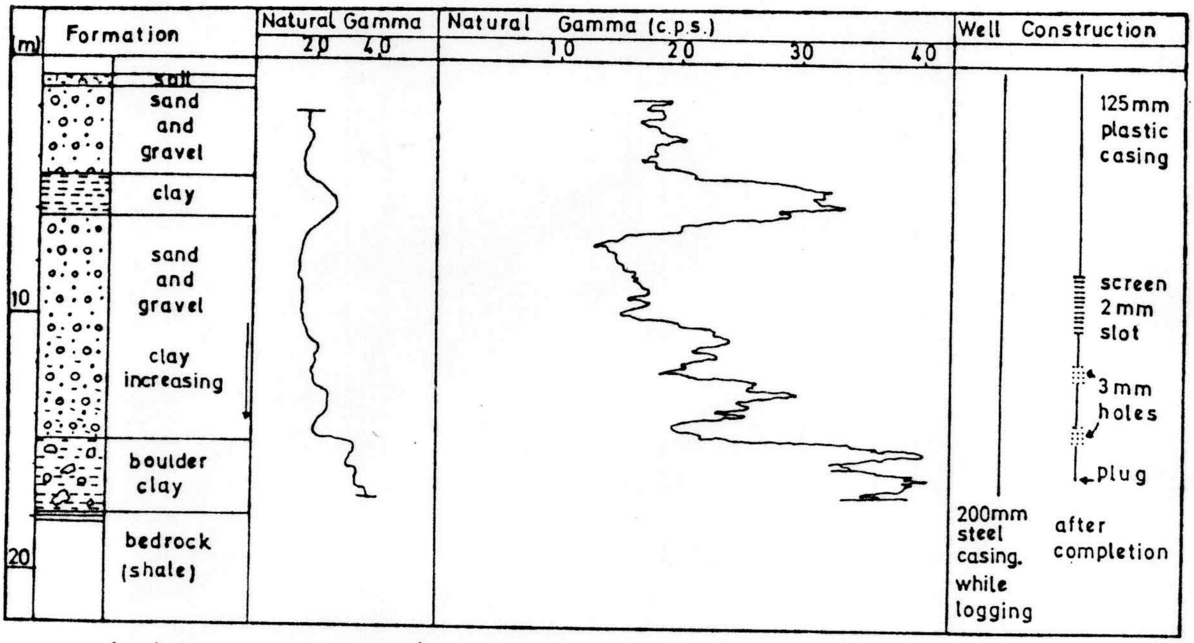
ISOPACH MAP OF THE KILMANAGH RIVER GRAVELS



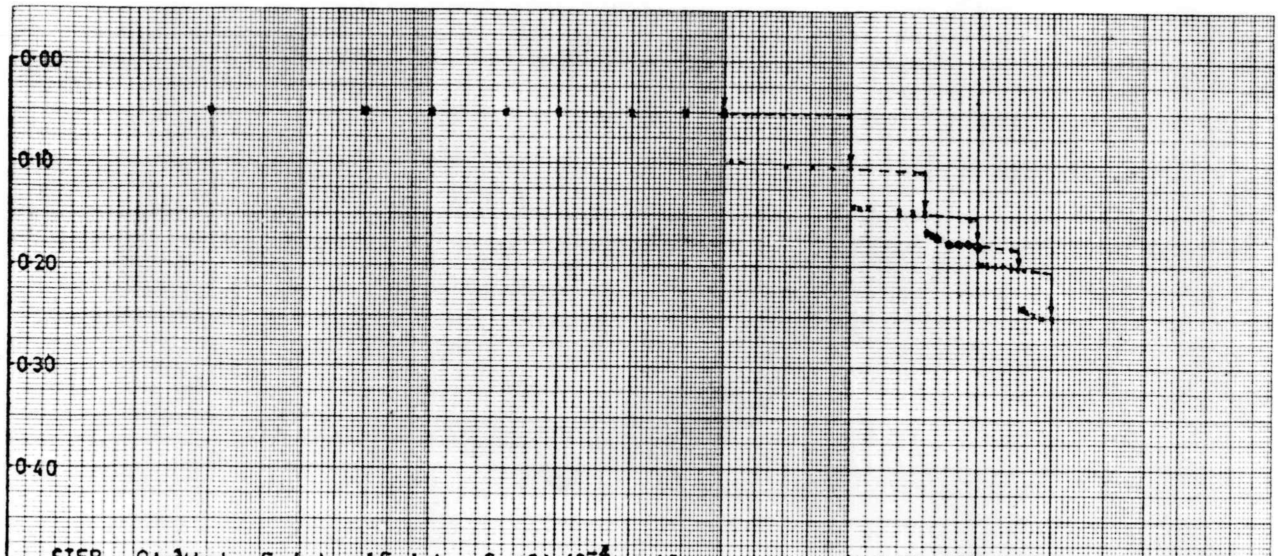
Profile B. Kilmanagh River Gravels



Profile F.



Geological and Geophysical Logs and Well Construction in borehole KNY 18/93 at Oldtown, County Kilkenny



STEP	Q(m³/day)	S_W(m)	ΔS_W(m)	$S_W/Q(\times 10^{-4})$	ΔQ
1	115	0·0550	0·0550	4·780	115
2	208	0·0975	0·0425	5·024	93
3	306	0·1325	0·0350	4·803	98
4	354	0·1585	0·0260	5·000	48
5	404	0·1815	0·0230	4·975	50
6	490	0·2280	0·0460	5·091	86

Well NO. KNY 18/93

Figure Time-Drawdown Curves of Step-Drawdown Test on Well NO. KNY 18/93

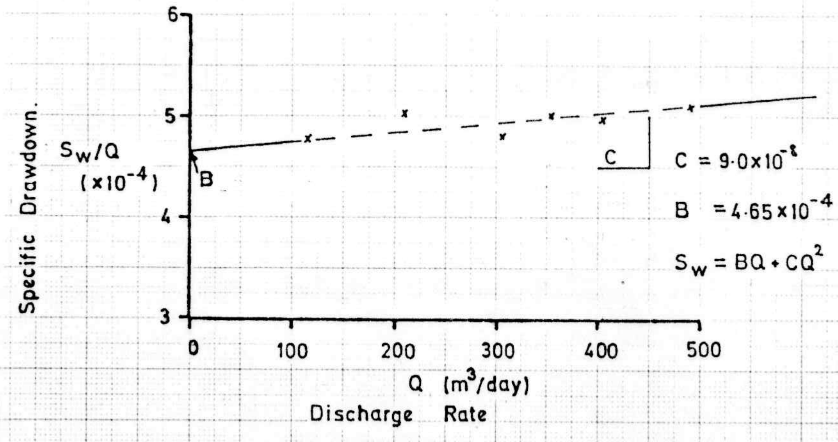


Figure Plot of S_w/Q for Well NO. KNY 18/93

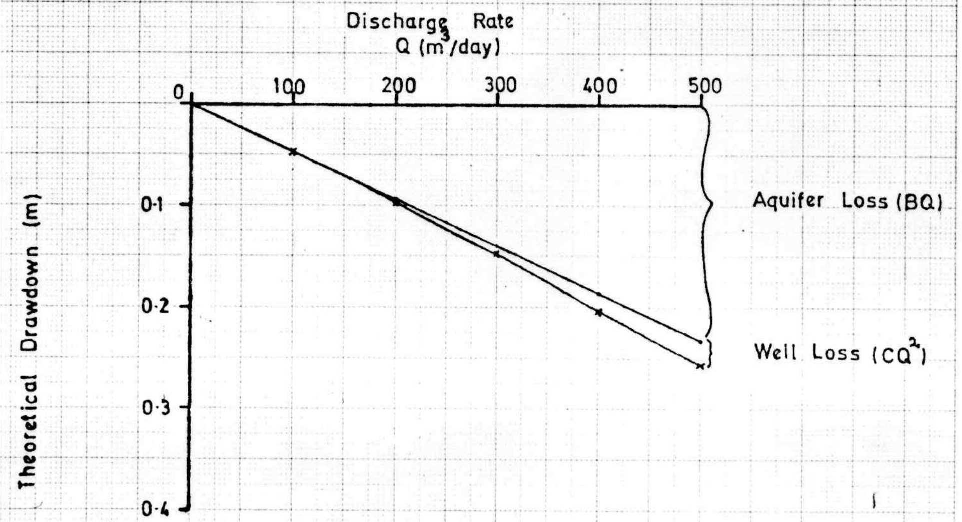


Figure Drawdown-Yield Curve for Well NO. KNY 18/93

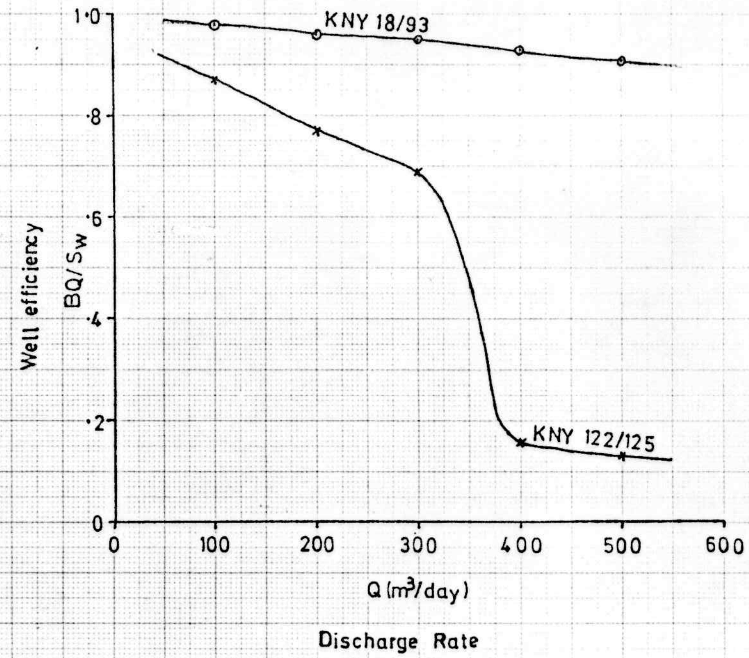


Figure Well Efficiency Curves of Wells in the Kilmanagh River Gravels

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GROUNDWATER DEVELOPMENT IN COUNTY WEXFORD

(from an original paper by the above author delivered to the Institute of Engineers on November 17, 1980.)

Fig. 1 shows the village of Kilmuckridge to be located some 19 kms. due east of Enniscorthy and 1.3 kms from the Irish Sea. Prior to 1980 Kilmuckridge Village and environs depended for their potable water on a small river abstraction scheme (Fig. 2); the daily demand being 409 m^3/day. The water quality was generally poor and the frequent pollution of the stream by silage effluent together with the lack of any spare capacity resulted in the Council being forced to seek an alternative source.

Geology

Fig. 1 shows the Kilmuckridge area to be underlain by rocks of Cambrian age that consist of greywackes and slates of the Bray Group. The solid geology is overlain nearly everywhere by an irregular blanket of Pleistocene (Ice Age) deposits consisting of fine uniform sands but with some marls and gravels also occuring. These unconsolidated deposits form part of a much wider geological formation known as the "Screen Sands" (Screen Village is some 13 kms to the south) and give the area a pronounced hummocky topography with valley to hill relief averaging 30 m.

Hydrogeology

A hydrogeological investigation by van Putten (1978) in the Blackwater area some 8 kms. to the south of Kilmuckridge and well records supplied by Mr. Sean Flood indicated that the Cambrian rocks were of little groundwater potential with wells in the greywackes and slates yielding at most 100 m^3/day. Therefore it was not surprising that a trialwell drilled at the treatment plant (Fig. 2), where the Cambrian rocks came to surface, yielded only 90m^3/day.

...Contd.

However, the 1978 survey indicated that wells drilled in the "Screen Sands" were capable of supplies in the region of 327 - 436 m^3/day; the yield varying with the permeability and thickness of the sandy deposits. It was decided therefore to investigate the environs of the existing abstraction point for a possible drilling site in the glacial overburden; the area to be tested by a resistivity survey.

Resistivity Survey

A resistivity survey was carried out by Minerex Ltd. over the area outlined by Fig. 2. The geophysical survey consisted of a series of Schlumberger electrical soundings (Fig. 3) designed to determine the thickness, composition and groundwater potential of the glacial overburden. The results of the electrical soundings were interpreted with the aid of a computer and the resulting bedrock contours are shown in Fig. 3.
The resistivity survey indicated that (a) the reservoir hill had a core of rock; (b) the hill to the south of the abstraction point masked a trough in the bedrock surface; and (c) that this trough was filled with low resistivity material, probably water bearing gravels.

Drilling and Test Pumping Results

A well drilled into the bedrock trough indicated by the resistivity soundings confirmed the existence of the bedrock surface depression (fig. 4) and intersected a course water bearing gravel confined by a thin marl horizon both overlain by some 44m. of uniform sand with little water. The well was test pumped for 72 hours at a rate of 925m^3/day with a drawdown of 12.55 m. resulting in a specific capacity of 73.6m^3/day/m. and a calculated transmissivity of 50m^2/day.

Acknowledgement

The Kilmuckridge hydrogeological survey was undertaken by the author when employed by Minerex Ltd.,Dublin, and he would like to thank the Directors of Minerex Ltd., and the Wexford County Engineer, Mr. G. Forde, for permission to publish the results.

SOLID GEOLOGY
of
COUNTY WEXFORD

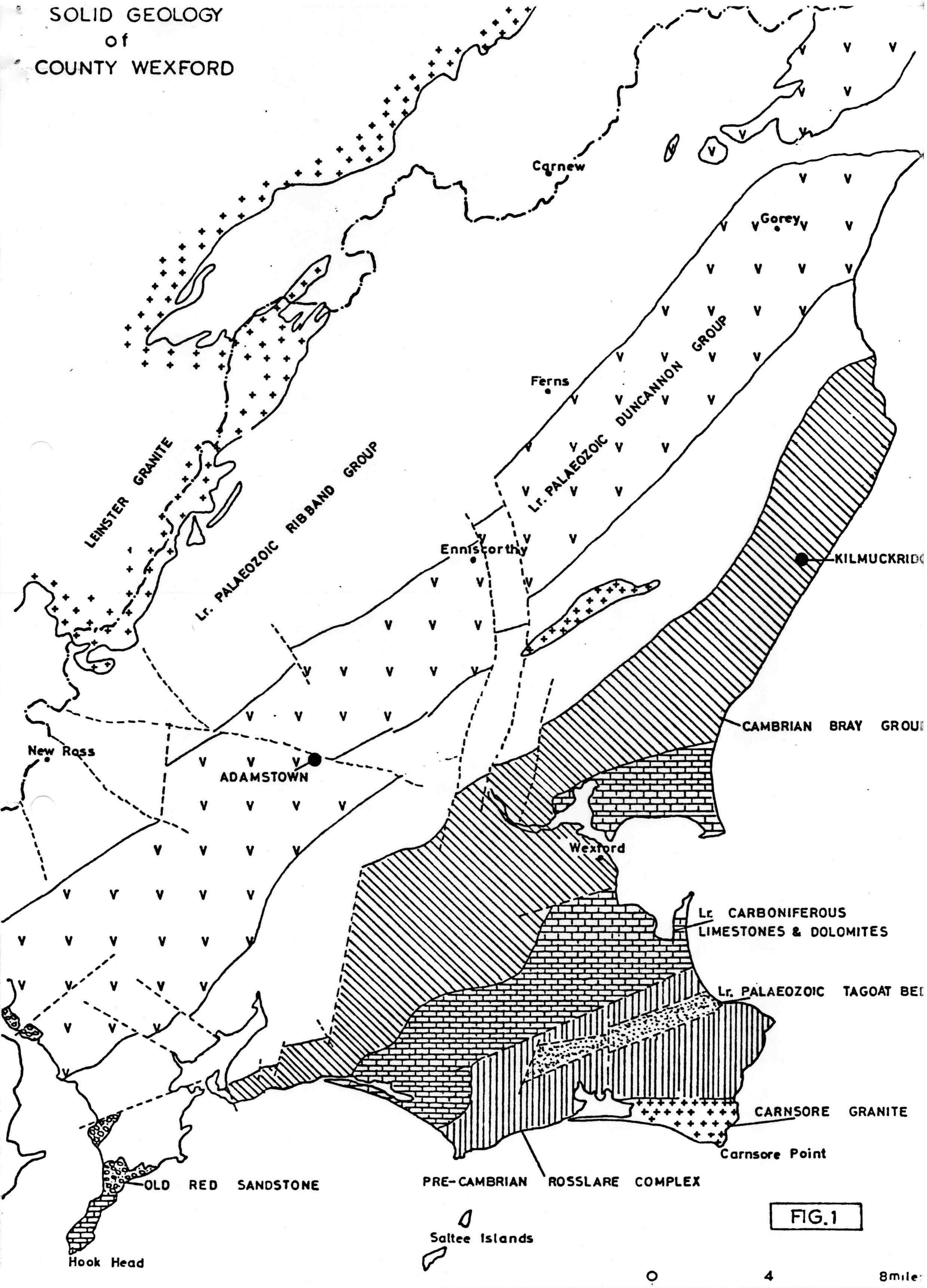


FIG.1

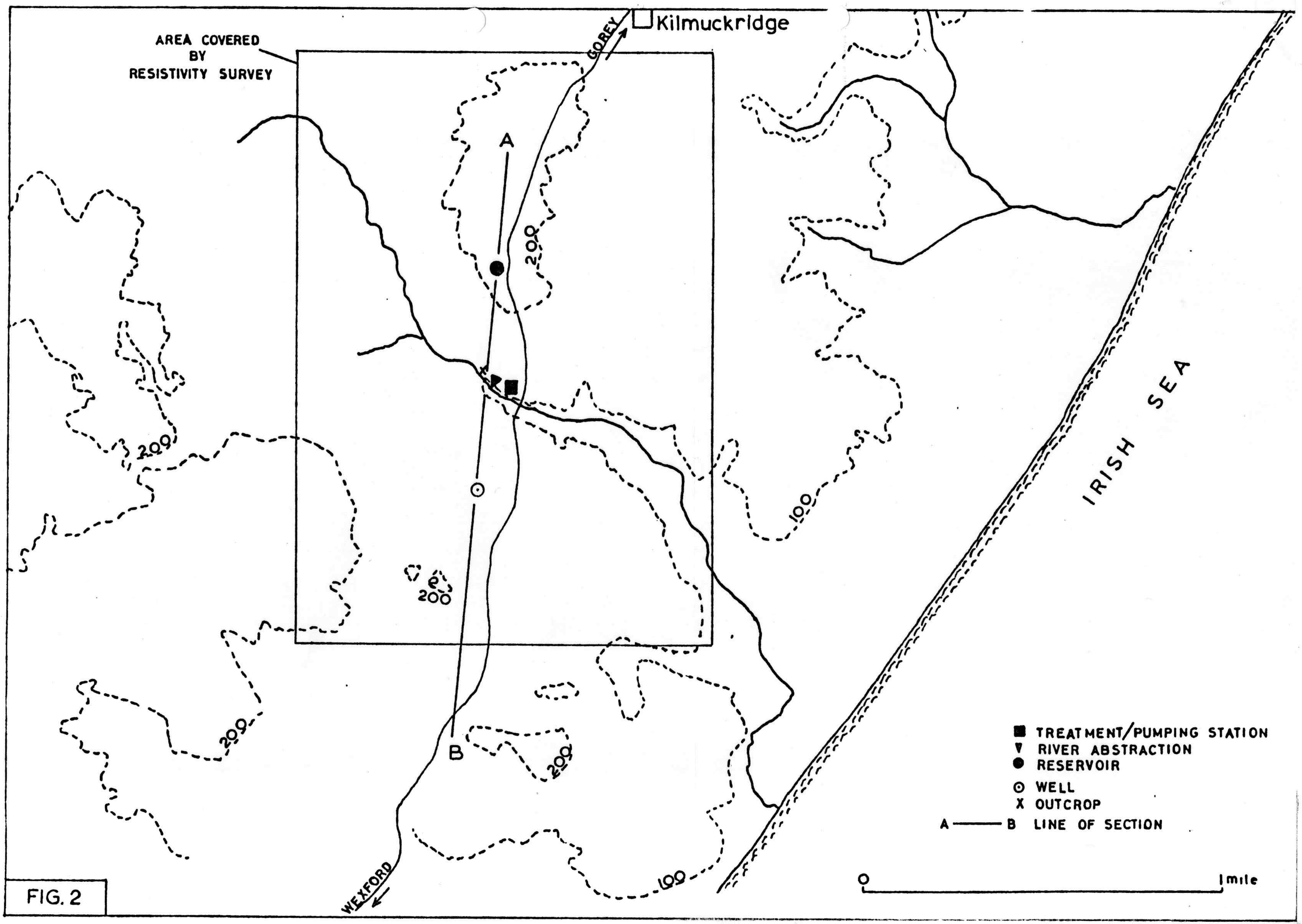

Kilmuckridge
AREA COVERED BY RESISTIVITY SURVEY
GOREY
WEXFORD
A
B
200
200
200
200
200
100
100
IRISH SEA
TREATMENT/PUMPING STATION
RIVER ABSTRACTION
RESERVOIR
WELL
X OUTCROP
A —— B LINE OF SECTION
0
1 mile

FIG. 2

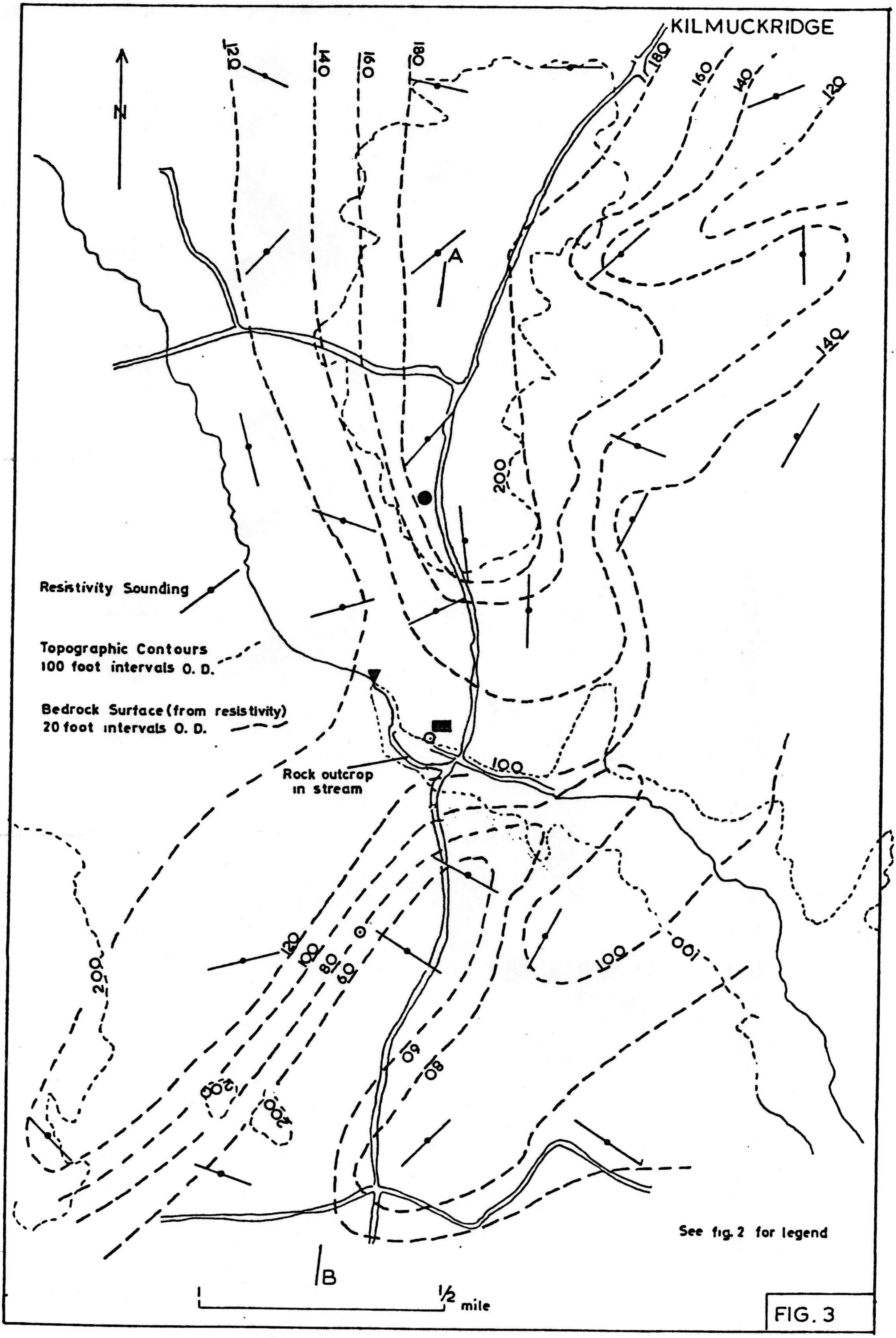
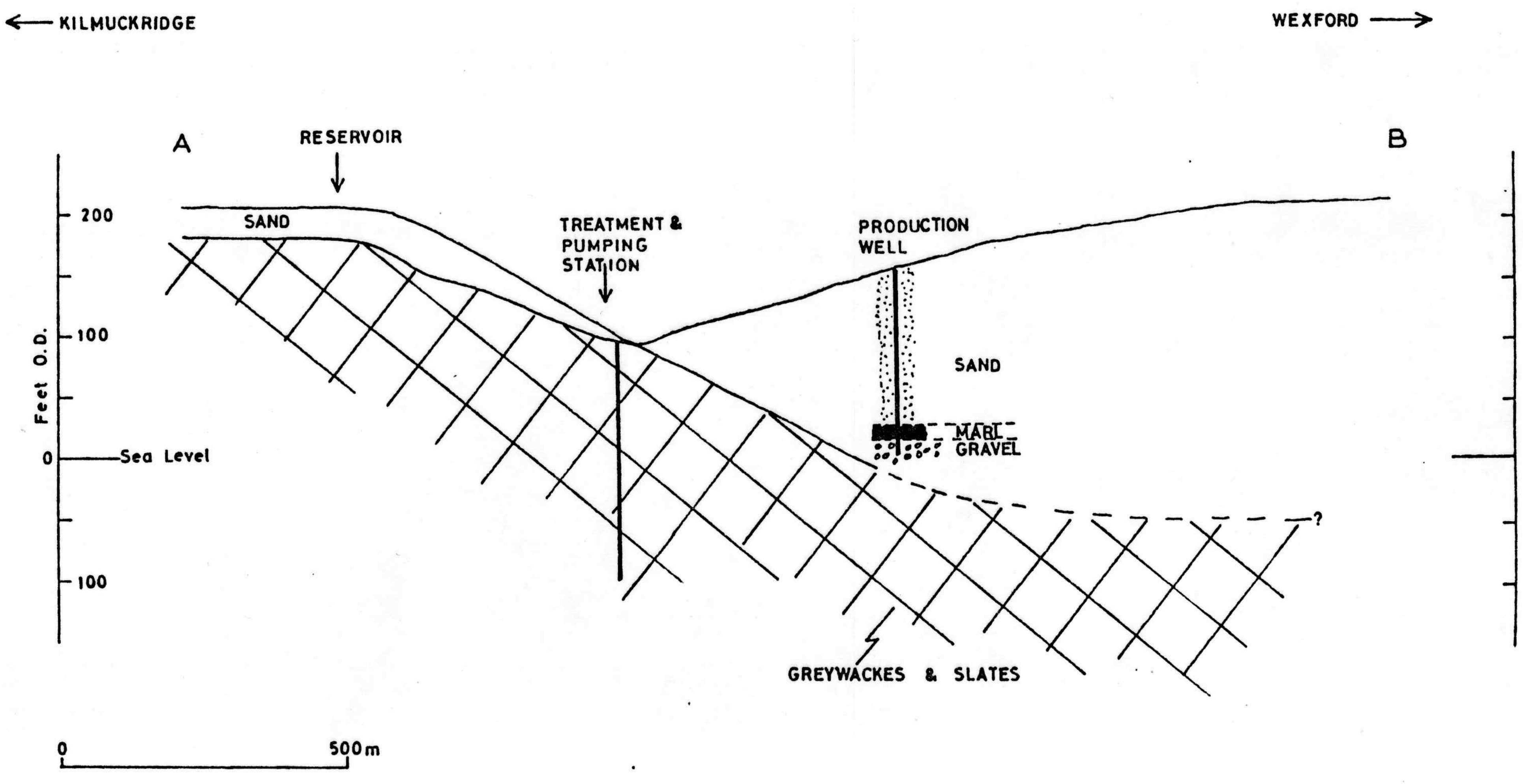

KILMUCKRIDGE
N
A
B
Resistivity Sounding
Topographic Contours
100 foot intervals O. D.
Bedrock Surface (from resistivity)
20 foot intervals O. D.
Rock outcrop
in stream
120
140
160
180
200
100
80
60
1/2 mile
See fig. 2 for legend

FIG. 3



KILMUCKRIDGE
WEXFORD
A
B
RESERVOIR
SAND
TREATMENT &
PUMPING
STATION
PRODUCTION
WELL
SAND
MARL
GRAVEL
GREYWACKES & SLATES
Feet O.D.
200
100
0
Sea Level
100
0
500m

FIG 4

SUMMARY

Gravel Aquifer Development - Two Case Histories

G.R.Wright, Groundwater Division, Geological Survey of Ireland.

A. Tallaght Groundwater Scheme for Dublin County Council.

Dublin County Council wanted to meet a short-term need for water in the Tallaght area, and requested a report on the prospects for groundwater in the vicinity. A local factory borehole had been successful and had confirmed the general geological indications that bedrock was generally absent in the area and some kind of gravel-filled buried valley might exist.

Four exploratory shell-and-auger boreholes were sunk, by Solmec Ltd., Dublin, in 1978, about 400 metres apart along a north-south line across the most likely axis of the trough.(see section). The two central boreholes (2 & 3) were the most promising, with substantial gravel layers met at depth, and the trough was proved to have a depth of over 40 metres below surface. Short pumping tests were carried out, using a temporary well screen, and these confirmed that the aquifers were well worth exploiting. Particle size analyses showed the gravels to be coarse and poorly sorted, and thus capable of 'natural development'. Production well yields of 60 - 90 m^3/h (13000 - 20000 gph) for BH 2 and over 100 m^3/h (22000 gph) for BH 3 were predicted.

Two production wells, 18 inches in diameter and equipped with 12 inch diam. plastic well screens, were drilled in 1979 by Groundwater Development Ltd., of Mallow, and were tested at rates of 82 m^3/h (18000 gph) (BH 2A) and 116 m^3/h (25500 gph) (BH 3A). The wells were then equipped with pumps and soon were brought into service to cope with water shortages in the spring of 1980.

B. I.D.A. Industrial Estate, Carrigtwohill, Co. Cork.

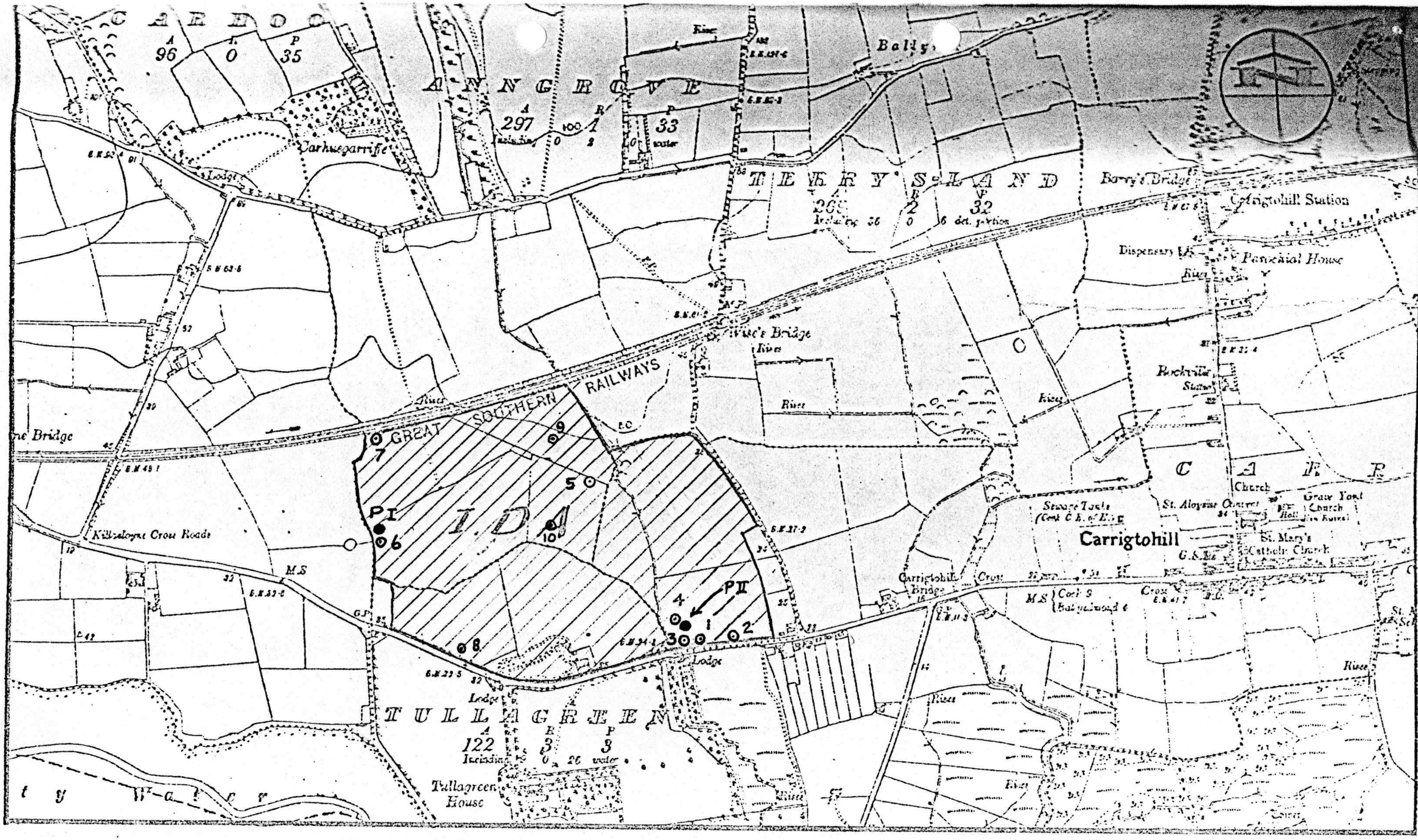
This is one of the sites around Cork Harbour where the IDA is encouraging industrialisation. Surface gravel deposits occur extensively in this area, and the existence of a gravel aquifer at depth had been known for some time, from boreholes at a nearby factory. The IDA site was investigated in 1977 by the drilling of 7 exploratory shell-and-auger boreholes to depths of from 21 to 46 metres below surface. The sediments were found to be very varied, but in general tended to be finer above and coarser below. The first four holes had trouble with very fine, silty, running sands, but finally the fourth hole found a coarse gravel aquifer between 34 and 41 metres deep. In BH 5 the deep gravel was only 4 metres thick, but BH 6 found an excellent gravel between 14 and 34 metres deep. (see section and map). Drilling was by Solmec Ltd.

Two production well were subsequently sunk to depths of 40m and 44m, by Fondedile Ltd, London, near BH 6 and BH 4, each with 8m of Johnson screen, and the tested yields were around 10000 gph and 5000 gph, which were comparitively disappointing.

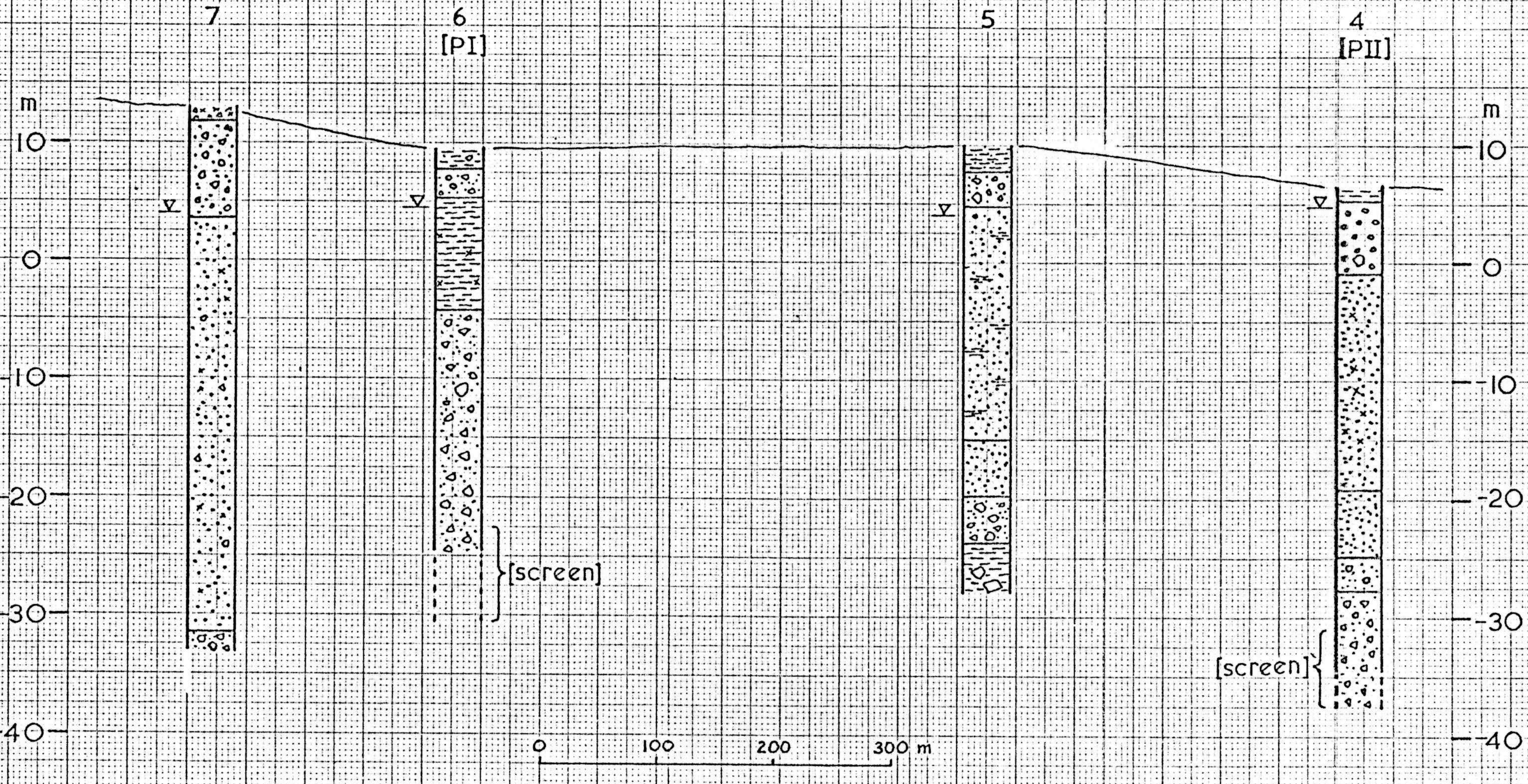
....

The two examples above had a number of features in common -
a) Favourable indications from previous boreholes and geological evidence that a gravel aquifer over 20m deep could exist.
b) Careful exploratory boring, with emphasis on good sampling.
c) Careful analysis of short pumping tests.
d) Very varied geological succession.
e) Final successful development with large-diameter wells and wellscreens.

Acknowledgements: Malachy Walsh & Partners, I.D.A., Solmec Ltd, Ground Water Development Ltd, and Dublin County Council.



6" To 1 Mile LOCATION MAP.	I.D.A. INDUSTRIAL ESTATE CARRIGTOHILL, CO. CORK	⊙ Investigation boreholes ● Production wells



I.D.A. INDUSTRIAL ESTATE
CARRIGTOHILL, CO. CORK

THE YAZOR GRAVELS

LEWIS CLARK, W.R.C.

1. INTRODUCTION

The Yazor Brook drains an area of about 50 km^2 west of Hereford and north of the River Wye. The Yazor runs parallel to the Wye for most of its length, then enters the Wye at Hereford. The Yazor is surrounded by high hills to the west and north but is separated from the Wye only by a subdued ridge running from Kenchester, through Breinton, to Hereford.

The lower, central parts of the Yazor Valley are infilled by superficial glacial and post-glacial sediments up to about 15 m in thickness. A significant proportion of these sediments are ill-sorted glacial-outwash sands and gravels which make up a local, but important, aquifer system: The Yazor Gravel Aquifer System.

Detailed hydrogeological investigations of the aquifer system including drilling and testing exploratory and test wells, together with a geophysical survey to delimit the gravel beds began under the Wye River Authority, assisted by the Water Resources Board and continued, after reorganisation, under Welsh Water Authority assisted by the Water Research Centre (WRC). As a follow-up to the hydrogeological investigations the Centre was asked to make a mathematical model of the Gravel Aquifer System.

2. GEOLOGY

The geological succession in the Yazor catchment is relatively simple comprising a thin veneer of superficial deposits overlying strata of Old Red Sandstone, Dittonian age. The Old Red Sandstone makes up the high hills to the west and north of the catchment, the very low ridge between the Wye and the Yazor, and also underlies the whole of the Yazor valley. The superficial deposits infill the centre of the Yazor valley and thin out onto the Old Red Sandstone hills. The junction between the two units is somewhat subjective because of the feather edge of the superficial deposits.

The Old Red Sandstone strata are mainly dark red, fine sandstones, siltstones and mudstones. No hydrogeological data are available from this formation within the Hereford area but by extrapolation from other areas it is expected to act as a fissured, indurated sandstone with low primary porosity and generally low transmissivity. The bulk transmissivity of the Old Red Sandstone is believed to be not greater than about 50 m^2/day.

The greater part of the superficial deposits in the Yazor catchment comprise the outwash sands and gravels which make up the aquifers of the Yazor Gravel Aquifer System. A typical section, from Sun Valley borehole No. 2 is:

Top Soil	2 ft	
Marl	12 ft	
Dirty Gravel	8 ft	Water level 23 ft bgl.
Mixed Gravel	12 ft	
Marl	2 ft	
Fine Gravel	4 ft	
Sandstone	2 ft	
Marl	3 ft	

The Yazor Gravel Aquifer System is typical of innumerable small valley-fill fluvio-glacial gravel aquifers.

The purpose of this brief case history is to illustrate the potential of gravel aquifers. The Yazor system covers a very limited area and is very thin - less than 10 m thick. This system, however, supports the light industry of Hereford. It provides the water supply for the world's biggest cider factory and for one of Britain's largest chicken processing plants.

The production boreholes were drilled by the percussion method and lined by steel wire-wound screen or bridge-slot screen. The yield for each borehole is generally around 100,000 to 300,000 gpd, although the mean daily withdrawal from the well is usually much lower.

Some figures for 1977 are:

		Mean Daily Discharge (000 gpd)	
1.	Abattoir	29	
2.	Crystallware Factory	34	
3.	Creamery	18	
4.	Bulmers Longland	236	
5.	4 Vat	16	
6.	Bulmers 14	4	(Not used Apr - Aug)
7	19W	131	
8.	20	65	
9.	21	69	
10.	22W	126	

The total borehole abstraction from the Yazor Gravels in 1978 totalled 530,213,000 gallons or 2.4 million m^3. This abstraction rate has been shown, by mathematical modelling, to be approaching the safe yield of the system.

The water balance for the Yazor System is:

Effective Rainfall	15.25		
River Flow (Run Off)		6.23	Run-off
Baseflow to the Wye		4.15	
Abstractions		2.36	- Infiltration
Loss to Sewers		2.51	
	15.25	15.25	

IAH SEMINAR - GRAVEL AQUIFER DEVELOPMENT - JANUARY 27 & 28, 1981

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This seminar has been organised by the committee of the Irish Group of the International Association of Hydrogeologists: Dr. D.J.Burdon, President, G.R.Wright, Secretary, and K.T.Cullen, Treasurer.

The organisers would like to thank all the speakers and their organisations for their presentations, Johnson Wellscreens for their films and for the well screen used in the demonstration well, Ingersoll Rand for their films and projection facilities, Dunnes Welldrilling for drilling the demonstration well and supplying a rig for the development demonstration, the Geological Survey and its Director, Dr.C.Williams, for projectors and many other facilities, and the management and staff of the Montague Hotel.

We should also thank all participants in the meeting.